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# Environmental Regulations and Technology
# The Dry Cleaning Industry

TRW Environmental Engineering Div.
Research Triangle Park, NC

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# Environmental Regulations and Technology

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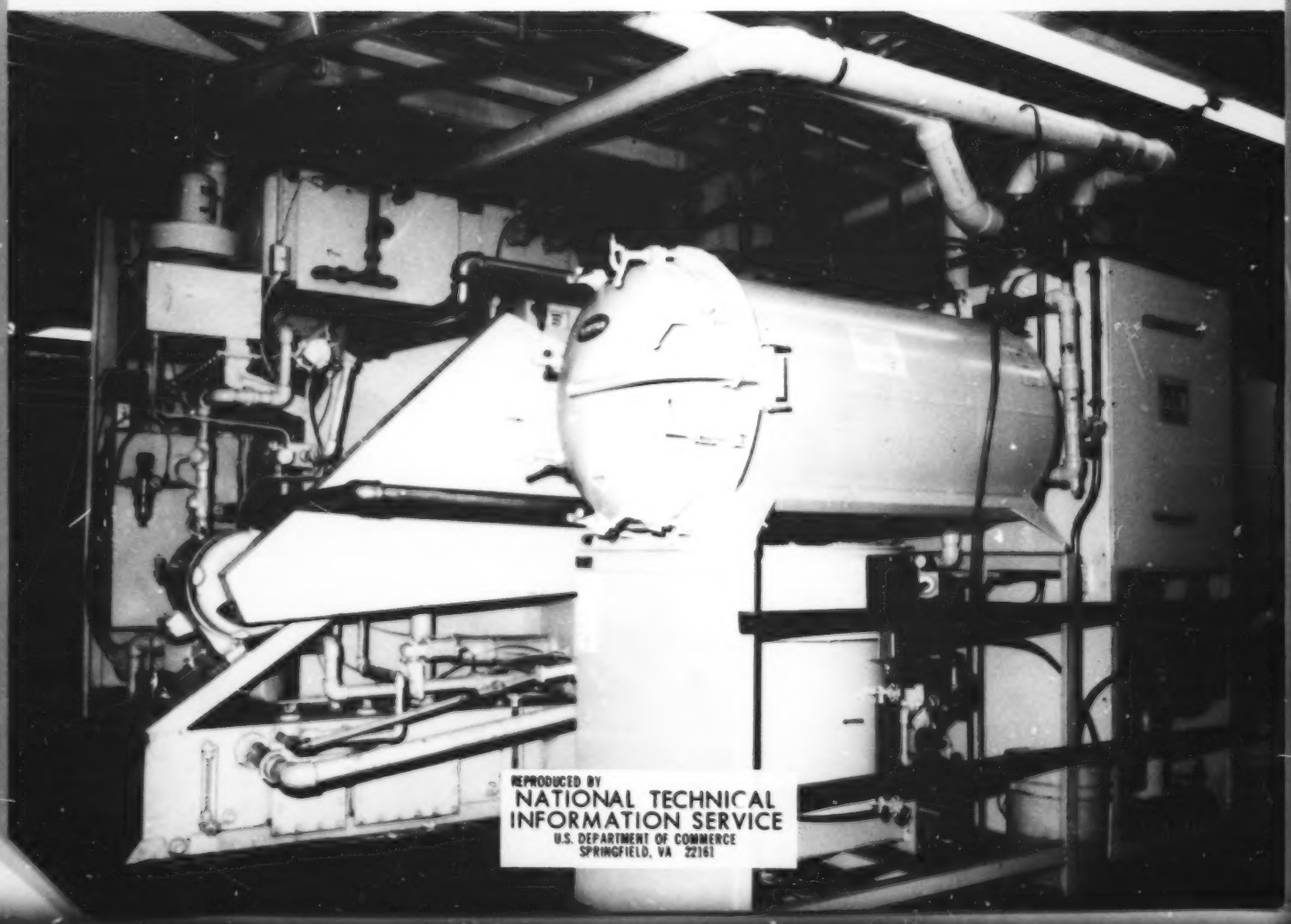

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16. ABSTRACT

This document reports current and proposed Federal pollution regulations that will affect the dry cleaning industry and describes several techniques that dry cleaning facilities can use to comply with regulations. Control technologies and costs for applying the technologies are discussed to reduce hydrocarbon emissions for the three solvent systems: perchloroethylene (perc), petroleum distillate (specifically Stoddard Solvent), and fluorocarbon (specifically F-113).

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May 1981

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Industrial Pollution Control Division
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and
Center for Environmental Research Information
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Garment dryers (left) and Stoddard washing machines (right)

This industrial awareness report was prepared by TRW Environmental Engineering Division in Research Triangle Park NC and the Centec Corporation in Reston VA. The report was reviewed by the Environmental Protection Agency, the National Institute of Occupational Safety and Health, and the Institute of Industrial Launderers. The Teasdale Fenton Cleaners in Cincinnati OH permitted photographs to be taken of their facility.

This report has been reviewed by the U.S. Environmental Protection Agency and approved for publication. The process alternatives, trade names, or commercial products are only examples and are not endorsed or recommended by the U.S. Environmental Protection Agency. Other alternatives may exist or may be developed that are applicable to the dry cleaning industry.

COVER PHOTOGRAPH: Dry-to-dry machine (75-lb capacity), carbon cartridge filter, and vapor condensor.

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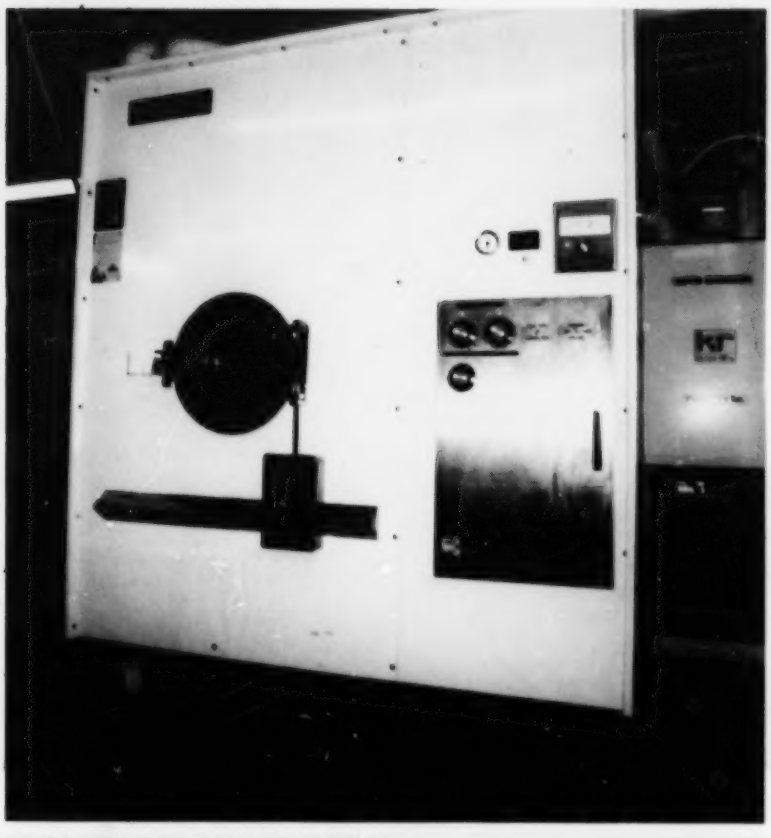
# 1. Introduction

This document reports current and proposed Federal pollution control regulations that will affect the dry cleaning industry and describes several techniques that dry cleaning facilities can use to comply with these regulations.

The report examines Federal, State, and local regulations in the four areas that may affect dry cleaners—air quality, water quality, solid wastes, and worker protection—and includes the following discussions:

- Methods available to dry cleaners for complying with existing and proposed regulations
- Control technologies for reducing hydrocarbon emissions for the three solvent systems: perchloroethylene (perc), petroleum distillate (specifically Stoddard solvent), and fluorocarbon (specifically F-113)
- Costs of applying these technologies

Control technologies described for reducing perc emissions are carbon adsorption, refrigeration/condensation, special housekeeping, and liquid and solid waste control. Control systems for petroleum solvent dry cleaners include carbon adsorption, condensation, incineration, muck stripping, special housekeeping, and liquid and solid waste control. For fluorocarbon solvent systems, special housekeeping and waste solvent treatment are the currently available control techniques; the discussion includes no others. Because the cost of F-113 is relatively high, solvent recovery is already practiced to make fluorocarbon machines competitive with perchloroethylene and petroleum machines.



Perchloroethylene dry-to-dry machine

## 2. Regulations

Federal regulations are being set by the U.S. Environmental Protection Agency (EPA) for air, water, and solid waste and by the Occupational Safety and Health Administration (OSHA) for worker protection. Most State and local regulations are similar to those set by EPA and OSHA. In some cases, however, State and local regulations may be more stringent.

### Air

EPA is now developing New Source Performance Standards (NSPS) for new dry cleaning facilities. Earlier, in December 1978, EPA published a control techniques guideline (CTG) document[a] to assist States in developing regulations for existing perchloroethylene sources. Currently, the Agency is studying techniques for controlling emissions from other dry cleaning solvents. The NSPS for perc plants were proposed on November 25, 1980 (45 FR 78174).

#### Perchloroethylene Solvents

The proposed NSPS for stationary sources would limit emissions of perc solvent from new, reconstructed, and modified dry cleaning equipment. Equipment is defined as reconstructed if the fixed capital cost of the new parts exceeds one-half the fixed capital cost of constructing a comparable new facility. An existing facility is defined as modified if any physical or operational changes are made that would increase the amount of perc emitted to the atmosphere.

The NSPS will require the use of emission control techniques that have been demonstrated to reduce perc emissions. These techniques have been developed considering costs, health effects, and environmental and energy impacts.

The proposed standards would establish different emission limits for the two segments of the industry: professional (commercial and industrial) and coin-operated dry cleaners. All dry cleaners would be required to:

- Use good operating and maintenance procedures to prevent liquid and vapor leaks
- Reduce perc content in waste materials to an acceptable level, for example, filter muck and distillation residue

Professional dry cleaners will be required to use a carbon adsorber, or equivalent, to limit the amount of perchloroethylene in the exhaust from dryers or dry-to-dry machines.[b]

The National Cancer Institute recently determined that perchloroethylene induces liver cancer in laboratory mice. Further studies on the concentrations to which humans are exposed to this solvent are in progress to determine if exposure to perc represents a carcinogenic risk for certain populations. Such a determination would require that the solvent be listed as a hazardous pollutant and could require additional Federal regulations for perc dry cleaning facilities.

[a]U.S. Environmental Protection Agency. *Control of Volatile Organic Emissions From Perchloroethylene Dry Cleaning Systems.* EPA 450/2-78-050. NTIS No. Pb 290-613. Dec. 1978.

[b]Dry-to-dry machines receive soiled garments, clean them in solvent, remove excess solvent, and heat up to vaporize remaining solvent so that clean clothes are dry when removed. Unlike transfer cleaning, which involves transferring clothes from a washer to a dryer, dry-to-dry cleaning is accomplished in a single unit.

Individual States already regulate existing sources to some extent. The three major points in EPA's CTG are recommendations for a carbon adsorber, good maintenance and housekeeping, and minimal losses in filter, still, and cooker residues.

Pennsylvania has adopted EPA's CTG for perchloroethylene. A New Jersey regulation, proposed on October 23, 1978, considers perc a toxic substance that must be discharged at least 40 ft (12 m) above grade and no less than 20 ft (6 m) higher than any structure within 50 ft (15 m) at an upward discharge velocity of 3,600 ft/min (1,100 m/min).

Several counties and municipalities have also enacted ordinances. Maricopa County, Arizona, requires the use of a carbon adsorber or a condensing system with an inlet temperature of less than 72° F (22° C) for all chlorinated hydrocarbons.

#### Petroleum Solvents

There are no existing Federal regulations governing plants using petroleum solvents, but Federal CTG and NSPS are being developed for new, reconstructed, or modified facilities. New technologies, such as petroleum recovery tumblers, will be considered when preparing new standards.

Although petroleum solvent facilities are not now regulated at the Federal level, they are regulated by some States and local jurisdictions. Many States have modeled their regulations after a rule originating in Los Angeles County, formerly called "Rule 66" and now defined as "Rule 442," which limits the emission of photochemically reactive petroleum solvents (namely, Stoddard solvent). Rule 66 states that the emission of petroleum solvents in excess of 40 lb/d (18 kg/d) must be reduced by 85 percent. The general effect of the regulation is to require that facilities cleaning more than 180 lb/d (82 kg/d) implement some type of control to reduce their uncontrolled emission rate.

Maryland, Illinois, Kentucky, Ohio, Colorado, and Indiana regulations generally follow Rule 66. Colorado's regulation is similar, except that it includes perc and F-113 dry cleaners consuming 25 gal/d (94 l/d) of solvent or more. In Washington, D.C., petroleum and perchloroethylene solvent regulations are similar to Rule 66.

#### Fluorocarbon Solvents

EPA's current policy on photochemical reactivity does not require control of any sources of trichlorotrifluoroethane (a chlorofluorocarbon). Chlorofluorocarbon is being considered for regulation as a designated pollutant, however, because F-113 and other fluorocarbons have been implicated in the depletion of the upper atmospheric ozone layer. (The layer serves as a shield against the rays of the sun that can cause skin cancer.) EPA is now conducting studies of this depletion effect.

## Water

The Federal Water Pollution Control Act of 1972 (Public Law 92-500), as amended by the Clean Water Act of 1977 (Public Law 95-217), prescribes effluent limitations guidelines for existing sources, standards for new sources, and pretreatment standards for sources discharging toxic pollutants. The 1977 amendments require that EPA publish a list (with periodic revisions) of industries to establish water pollution standards. The dry cleaning industry was combined with eight others under the classification "Auto and Other Laundries." A Technical Support Document was prepared by EPA's Office of Water Planning and Standards in August 1979 to provide the technical background data required to develop effluent guidelines for the dry cleaning industry.

Two sources of wastewater from dry cleaning are the solvent-water separator and the noncontact cooling water used for solvent vapor condensation. Water is usually added to the solvent bath at a rate of only 0.004 to 0.02 gal/lb (30 to 200 $cm^3$/kg) of material cleaned. The proportions of water to solvent are much less than those used in some other industries in the Auto and Other Laundries group, for example, car washes and wet laundries.

Effluent limitations, when adopted, will be based on the concentration of the pollutants in the effluent, the degree to which pollutant loadings can be reduced by demonstrated control technologies, and the financial ability of dry cleaners to purchase and operate control equipment. The dry cleaning industry may be exempted from water regulations if EPA determines that the control systems are not cost effective, quantities are too small to cause concern, or concentrations are too dilute to be harmful. If EPA proposes standards, interested persons will have the opportunity to comment.

## Solid Waste

Under the Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act (RCRA) of 1976 (Public Law 94-580), EPA has proposed rules[c] specifically listing perchloroethylene as a hazardous waste. Stoddard solvent and F-113 may

[c]U.S. Environmental Protection Agency. "Hazardous Waste: Proposed Guidelines and Regulations and Proposal on Identification and Listing." *Federal Register*, 43(243):58946-59028. Dec. 18, 1978.

also be listed as hazardous wastes under the category "halogenated solvent and solvent recovery still bottoms."

All dry cleaners are responsible for identifying materials they handle that are or may be hazardous wastes. Generators of hazardous waste producing more than 2,205 lb/mo (1,000 kg/mo), or small generators [that is, those that produce less than 2,205 lb/mo (1,000 kg/mo) of hazardous waste] producing "acutely hazardous" waste, must have notified EPA of their hazardous waste activities by November 19, 1980. Small generators are excluded from the notification requirement if their hazardous wastes are not defined in the regulations as acutely hazardous. Since EPA began issuing identification numbers to all generators on November 19, 1980, an applicable generator of hazardous wastes must implement a manifest (or tracking) system. Again, small generators of hazardous waste that is not defined as acutely hazardous are exempt from implementation of the manifest system.

A few States have regulations governing solid wastes containing dry cleaning solvents. Washington and New Jersey have enacted laws identifying perc and F-113 as hazardous wastes that must be taken to special waste-handling plants. Rhode Island has a similar regulation for perc. Texas and Oregon have implemented a manifest system whereby hazardous wastes must be tracked from the time of their generation to the time of their storage, treatment, or ultimate disposal. Oregon limits sanitary landfills to 200 lb (91 kg) of halogenated hydrocarbons per generator per month, and requires that all generators of solid wastes "shall use the best practicable methods to reduce the amount of waste, and to reuse, recycle, recover, or treat it." The Oregon limits apply to perchloroethylene and trichlorotrifluoroethane. Although Texas and many other States do not yet consider perc and F-113 to be hazardous wastes, it should be emphasized that they are so considered in the proposed Federal solid waste regulations.

**Table 1.**

OSHA Standards for Occupational Exposure to Dry Cleaning Solvents

| Standard | Concentration (ppm) | | |
|---|---|---|---|
| | Perchloroethylene | Petroleum | Fluorocarbon |
| Threshold limit value (no effects below this level)[a] | 100 | 100 | 1,000 |
| Maximal 8-h time-weighted average | 100 | 500 | 1,000 |
| Maximal concentration, general | 200 | NA | NA |
| Maximal 5-min concentration (allowed once each 3 h) | 300 | NA | NA |

[a]American Conference of Governmental Industrial Hygienists.

Note.—NA = not applicable.

SOURCE: Laundry-Cleaning Council, *The Safe Handling of Perchlorethylene Drycleaning Solvent*, Chicago IL, Laundry-Cleaning Council, 1980.

## Worker Protection

The National Institute for Occupational Safety and Health (NIOSH) provides recommendations to OSHA for setting standards and the regulatory process to control health hazards in the workplace. The current OSHA rules and regulations on dry cleaning solvent vapors[d] have not changed since their original publication in the early 1970's. Table 1 shows occupational exposure limits for each of the three solvents, but these standards could change as more information becomes available on health effects.

### Perchloroethylene Plants

For occupational exposure to perc, the current OSHA standard is 100 ppm, 8-h time-weighted average. In July 1976, NIOSH recommended reducing this exposure limit to 50 ppm as a time-weighted average for up to a 10-h workday, 40-h workweek, not to exceed a ceiling concentration of 100 ppm during a sampling time of 15 min. The 50-ppm limit is still under consideration.

The 50-ppm standard has been recommended to prevent reported effects of perchloroethylene on the human nervous system, eyes, skin, respiratory tract, and liver. Table 2 shows average responses to inhalation of perc vapor, according to the Laundry-Cleaning Council.[e] Data compiled by the Laundry-Cleaning Council indicate that emissions from poorly operated perc plants may reach or exceed 600 ppm.

### Petroleum Plants

The current OSHA standard for occupational exposure to petroleum

[d]Occupational Safety and Health Administration. "Toxic and Hazardous Substances." *Code of Federal Regulations*, Title 29, Part 1910.1000, pp. 574-580. July 1, 1979.

[e]Laundry-Cleaning Council. *The Safe Handling of Perchlorethylene Drycleaning Solvent*. Chicago IL, Laundry-Cleaning Council. 1980.

**Table 2.**

Average Responses to Inhalation of Perchloroethylene Vapor

| Concentration (ppm) | Effect |
|---|---|
| 50 ..... | Odor threshold (very faint) to unacclimated. No physiological effect, 8 h. |
| 100 ..... | Odor (faint) definitely apparent to unacclimated, very faint to imperceptible during exposure. No physiological effect, 8 h. |
| 200 ..... | Odor (definite) moderate to faint upon exposure. Faint to moderate eye irritation (eye irritation threshold, 100-200 ppm). |
| 400 ..... | Odor (strong) unpleasant. Definite eye irritation. Slight nose irritation. Definite incoordination, 2 h. |
| 600 ..... | Odor (strong) very unpleasant but tolerable. Definite eye and nose irritation. Dizziness, loss of inhibitions, 10 min. |
| 1,000..... | Odor (very strong) intense, irritating. Marked irritation to eyes and respiratory tract. Considerable dizziness, not likely to be tolerated voluntarily, 2 min. |
| 1,500..... | Odor (almost intolurable) gagging. Irritation (almost intolerable) to eyes and nose. Complete incoordination within minutes to unconsciousness within 30 min. |

SOURCE: Laundry-Cleaning Council, *The Safe Handling of Perchlorethylene Drycleaning Solvent*, Chicago IL, Laundry-Cleaning Council, 1980.

solvent vapor is 500 ppm, 8-h time-weighted average, to prevent effects on human health. Overexposure to Stoddard solvent is accompanied by such recognizable symptoms as irritation of the eyes, nose, and throat and possibly slight dizziness or headache. Few experimental data have been published on industrial exposure to petroleum solvent vapors.

### Fluorocarbon Plants

Fluorocarbon dry cleaning solvent has a higher threshold limit value than Stoddard solvent or perchloroethylene. The average employee can safely work 8 h/d in an atmosphere containing up to 1,000 ppm of F-113 vapor. Under normal operating conditions for a properly functioning machine, there is no need for any special machine ventilation. OSHA recommends that both coin-operated and professional dry cleaners have an emergency exhaust ventilation system available in case of a major solvent spill.

### State and Local Regulations

Whereas most State and local jurisdictions follow OSHA's recommendations for all three solvents used by professional dry cleaners, the New York metropolitan area has promulgated additional regulations specifically for coin-operated cleaners. These regulations apply to both perchloroethylene and fluorocarbon solvents. Depending on the number of machines it contains, a coin-operated service must meet the following room ventilation standards:

- 250 $ft^3$/min (7.1 $m^3$/min) per machine for 1 to 4 machines
- 200 $ft^3$/min (5.7 $m^3$/min) per machine for 5 to 8 machines
- 150 $ft^3$/min (4.2 $m^3$/min) per machine for 9 to 16 machines
- 100 $ft^3$/min (2.8 $m^3$/min) per machine for more than 16 machines

Coin-operated facilities are required to provide 500 $ft^3$/min (14 $m^3$/min) total emergency ventilation (usually with a fan), including the ventilation described above.

# 3. Methods of Compliance

## Air Regulations

### Perchloroethylene Plants

Requirements for reducing perchloroethylene dry cleaning emissions are similar under the proposed NSPS and the State regulations based on the CTG. All dry cleaners would be required to follow good maintenance and housekeeping practices and to minimize filter, still, and muck cooker residues. Further, professional cleaners would have to install a carbon adsorber or equivalent control system to collect emissions from the dryer or dry-to-dry machine exhaust.

Good housekeeping practices can minimize all liquid leaks and most gaseous solvent leaks in the system. Liquid leaks should be located quickly and corrected promptly, and, as a rule, they are easily detected by sight. Brown residue (nonvolatile material) left on the lower side of the leak indicates solvent loss, as does a dripping of solvent. Possible areas of liquid leakage or solvent loss include:

- Hose connections, unions, couplings, and valves
- Machine door gasket and seating
- Filter head gasket and seating
- Pumps
- Base tanks and storage containers
- Water separators (solvent lost in water because of poor separation)
- Filter sludge recovery (solvent lost in sludge by improper or incomplete recovery)
- Distillation unit
- Divertor valves
- Saturated lint from lint basket
- Cartridge filters

Vapor leaks, which can be detected by smell and with hydrocarbon detectors or soapy water, should be repaired immediately. Vapor leaks and solvent loss occur in several ways:

- The seals on dryer deodorizing and aeration valves need periodic replacement to prevent leakage.
- Solvent is lost through holes and openings in air and exhaust ducts.
- Doors left open and faulty gasketing result in leakage.
- Button traps and lint baskets should be opened only as long as necessary for cleaning because they contain residual solvent that can evaporate.
- Lint screens and bags, fan blades, and condensers can adversely alter operation of recovery systems by being clogged or caked with lint.
- Overloading and underloading can increase losses: overloading makes drying difficult and results in incomplete extraction of solvent, whereas underloading increases emissions per pound of clothes cleaned because some losses are inherent in the system.

To prevent significant evaporation of volatile organic compounds from the disposal of waste solvent generated by filters and solvent stills, a dry cleaning operator can minimize the perchloroethylene content before disposal by employing good extraction techniques.

Muck cookers and cartridge filters are used to reclaim solvent in perc systems. Cooking solvent out of filter materials in muck cookers can reduce the amount of perc lost to below 25 percent by weight. Proper still operation can reduce solvent content in distillation bottom wastes to less than 60 percent by weight. Oil cookers, similar to muck cookers, can further reduce perchloroethylene content to about 1 percent by weight.

The contained housing design of most cartridge filters facilitates filter removal and replacement and eliminates fugitive emissions. Cartridge filters can be applied to low soil loadings, such as commercial operations. As a rule, these filters should be drained in their housings a minimum of 24 h before disposal.

#### Petroleum Plants

It is expected that a future CTG and NSPS for petroleum plants will recommend good housekeeping and maintenance and good extraction techniques. Possible control technologies—discussed in more detail in Section 4—include carbon adsorption, petroleum recovery tumblers, incineration, and muck stripping (a technique for processing filter muck to recover solvent).

#### Fluorocarbon Plants

Fluorocarbon may affect the upper atmosphere adversely by depleting the ozone layer. If EPA regulates F-113 as a designated pollutant for this reason, good housekeeping and maintenance and solvent waste treatment control techniques (see Section 4) are likely to be required.

## Water Regulations

Dry cleaning effluent concentrations are low compared with laundries, carpet and upholstery cleaners, and car washes. If EPA establishes water regulations in the future, treatment processes will also be identified that will enable the dry cleaning industry to comply with them.

## Solid Waste Regulations

Current and planned Federal solid waste regulations are based on RCRA. They are being developed to control major sources of hazardous wastes. Size cutoffs anticipated for these regulations will exempt all but the larger industrial dry cleaners from having to control the amount of solvent requiring storage, transport, and disposal.

Dry cleaning waste products may include used cartridge filters and residue from regenerable filters and solvent stills. The waste products can be controlled by incineration or by reclaiming solvent from the waste material. Incineration is feasible for petroleum solvent still wastes, which may be disposed of in incinerators designed for this compound or burned as an auxiliary fuel in an existing steam boiler. Because perchloroethylene is not flammable, incineration is not an alternative.

## Worker Protection Regulations

#### Perchloroethylene Plants

Proper work practices in the routine handling and use of perchloroethylene should ensure compliance with employee exposure standards. Adequate ventilation for a perc dry cleaning room requires well-sealed ductwork connections and clean, tempered replacement air. The ventilation system and all dry cleaning equipment should be checked periodically for leaks (refer to earlier section on methods of complying with air regulations). The dry cleaning apparatus should draw air automatically into the machine when the loading door is open to prevent vapors from escaping into the room. To the extent possible, employees should keep perc-saturated materials away from breathing zones. Carbon adsorption filters in the dry cleaning units need to be regenerated regularly. Lint, filter residue, and distillation wastes should be placed in covered containers and stored outside the building.

Perchloroethylene, like most organic solvents, removes natural oils from the skin, so prolonged or repeated contact should be avoided. Employees whose clothes become saturated with solvent should change into clean, dry garments.

#### Petroleum Plants

Because dry cleaning plants are designated Class II and Class III fire hazards by the National Fire Protection Association, all cleaning room equipment must be explosion proof.

The volatile nature of Stoddard solvent necessitates ventilation of all dry cleaning plants. National safety codes indicate that the room air should be changed every 2 to 3 min. Natural ventilation (by doors and windows) and forced ventilation (by wall and ceiling fans) can keep the ambient petroleum concentration to a minimum. Elevated hoods, placed close to the transfer area between washer and dryer, can reduce the concentration of solvent in ambient air.

#### Fluorocarbon Plants

Machines using fluorocarbon solvents are designed as nonvented systems with refrigerated condensers to prevent the escape of large amounts of solvent into the workplace. The average employee can work safely for 8 h in an atmosphere containing up to 1,000 ppm of F-113 vapor. Because saturated fluorocarbon vapors at room temperature are 2.5 times heavier than air, they will concentrate at floor level, where a properly designed ventilation system can easily exhaust them from the building.

# 4. Emission Control Technology

This section discusses emission control technologies for dry cleaning plants and estimates their application costs. The control systems available for the solvents overlap to some extent.

Carbon adsorption is a demonstrated control technology for both perchloroethylene and Stoddard solvent dry cleaning systems. Carbon adsorbers are now used by 35 to 40 percent of the commercial perc systems and by about 50 percent of the industrial perc systems. The use of this technology results from economic necessity; substantial solvent recovery is essential during drying to make perchloroethylene competitive with less expensive petroleum solvents. EPA's Office of Research and Development (through the Industrial Environmental Research Laboratory in Cincinnati) has conducted performance tests in Anaheim, California, on a typical industrial petroleum plant dryer equipped with a carbon adsorption system furnished by EPA.[1]

A water-cooled condenser system similar to the reclaiming dryers used by most perc dry cleaning plants has been developed recently and is now used by about 100 petroleum plants. EPA is acquiring information on the operation of recovery dryers and historical data on their safety because there may be an explosive hazard when the solvent vapor concentration exceeds the lower explosive limit.

No control technology exists for recovering solvent from the dryer exhaust for F-113 machines because these nonvented systems have built-in control devices.

[1]U.S. Environmental Protection Agency. *Demonstration of Carbon Adsorption Technology for Petroleum Dry Cleaning Plants.* EPA 600/2-80-145. June 1980.

Other available control techniques include muck stripping and incineration for petroleum plants, and good housekeeping and maintenance practices and solvent waste treatment methods for all three solvents.

## Perchloroethylene Solvent

### Carbon Adsorption

Activated carbon has been used in a variety of applications for the removal of organic compounds from gaseous streams by adsorption, that is, the property of a surface to retain molecules of a fluid with which it has come in contact. Perchloroethylene and petroleum can be easily adsorbed on carbon. Petroleum units, however, need a much larger carbon adsorption system because dilution of petroleum solvent, for safety reasons, increases the total air flow requirements through the control system. Vapor adsorption is a simple process in which solvent-laden air is pulled into the system by a fan and pushed through the carbon bed. When the carbon bed becomes saturated, steam is introduced to flush out trapped solvent. This step is known as desorption or regeneration. The solvent-laden steam passes into a cold-water condenser, and the solvent, which is recovered in a water separator, is suitable for reuse.

A typical commercial carbon adsorption unit has one carbon canister, which is regenerated at the end of each day. A large industrial adsorption unit may be a single unit or may contain multiple canisters so that some can be used while others are being regenerated. Carbon canisters must be desorbed frequently to achieve maximal solvent recovery and reduction in air emissions. Individual schedules for desorption should be established for each installation, based on the highest number of cleaning loads between desorption operations.

Under controlled conditions, perchloroethylene solvent has been measured at 25 ppm or less at the adsorber outlet and can result in better than 96 percent emission reduction from the dryer exhaust.[9] Space requirements for the adsorber range from 12 $ft^2$ (1.1 $m^2$) for a 40-lb- (18-kg-) capacity dryer to 60 $ft^2$ (5.6 $m^2$) for a 300-lb- (140-kg-) capacity dryer. These area estimates include piping, canister, and duct-work.

### Refrigeration/Condensation

A refrigerated condenser solvent recovery unit provides an alternative to the carbon recovery system for perchloroethylene dry cleaners.

The solvent-laden air from the cleaning machine is cooled to a very low temperature to strip it of solvent and is then recirculated to the machine where it is reheated for drying. The cooling effect is achieved by a refrigeration unit, which lowers the temperature of the air to below the dew point of the vapor, causing it to condense and drain to a water separator. The recovered solvent is then fed into a storage tank. Existing data on these units show that they can achieve an emission reduction comparable to that of the carbon recovery system.

Application of refrigeration/ condensation to perc dry cleaners is relatively recent. The equipment is not currently available for all dryer sizes, but availability should improve if demand is sufficient.

[9]U.S. Environmental Protection Agency. *Perchloroethylene Dry Cleaners—Background Information for Proposed Standards.* EPA 450/3-79-029a. Aug. 1980.

**Table 3.**

Typical Solvent Losses in Uncontrolled Petroleum Dry Cleaning Plants

| Source | Average loss per 100 lb clothing (lb) |
|---|---|
| Dryer losses: | |
| Washer with separate extractor | 11.9 |
| Washer-extractor: | |
| Front loading | 13.9 |
| Side loading | 17.2 |
| Retention in filter muck (drained): | |
| Screen or rigid tube filter | 9.6 |
| Regenerative filter | 5.1 |
| Retention: | |
| In paper cartridges | 0.8 |
| In still residue | 1.0 |
| Miscellaneous | 0.7 |

SOURCE: U.S. Environmental Protection Agency, "Control Techniques Guidelines Document for Petroleum Solvent Dry Cleaning" (final draft in preparation), EPA Contract No. 68-02-3174/33, 1980.

## Petroleum Solvent

### Carbon Adsorption

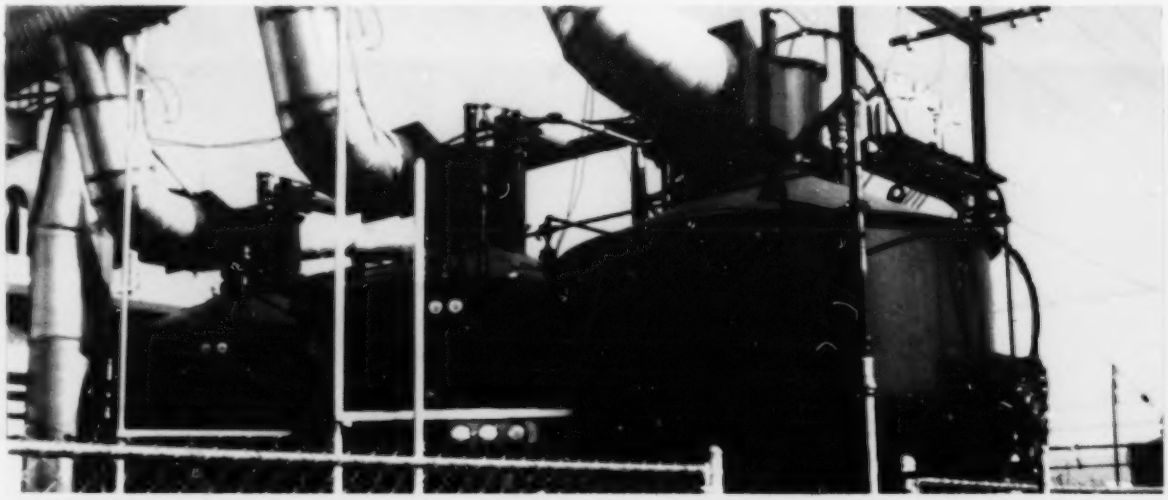
The carbon adsorption process for petroleum systems is similar to that described for perchloroethylene systems.

At present, carbon adsorption is used in only one industrial petroleum dry cleaning plant, which is located in Anaheim, California. The Anaheim plant is large, averaging 250 lb (110 kg) of articles per load and processing about 14 loads per day, or approximately 17,500 lb (7,900 kg) of articles per week. The total uncontrolled emission rate for this plant before the installation of the carbon adsorber was 24.4 lb/100 lb (24.4 kg/100 kg) of clothing cleaned. Table 3 gives the typical emission rates for various equipment types in an uncontrolled petroleum dry cleaning plant. The carbon adsorption unit reduced dryer exhaust emissions by 95 percent, as measured by a Beckman Model 400 hydrocarbon analyzer. Consequently, the overall plant emission rate was reduced to 16 lb/100 lb (16 kg/100 kg) of clothing cleaned. Emission controls in other areas of the plant could reduce the overall plant emission rate even more.

### Condensation

A condensation solvent recovery dryer has been marketed recently to replace conventional dryers. Its use of steam-heated coils to drive off the solvent contained in the fabrics is similar to the operation of a conventional dryer. The major difference is that this unit uses water-cooled coils to condense the solvent vapors. In a separator, the solvent is separated from the condensed liquid and sent to a storage tank for subsequent reuse in the cleaning operation.

Condensation solvent recovery is a new technology for petroleum dry cleaners. At present, only about 100 plants use the system, even though its efficiency in reducing emissions that would be exhausted from a conventional dryer is approximately 90 percent. This emission reduction rate is comparable to a carbon recovery system. Condensation solvent recovery systems currently are available in two sizes—50 lb (23 kg) and 105 lb (48 kg).



Petroleum dry cleaning carbon adsorption system (8,400 actual $ft^3$/min), Valley Industrial Services, Anaheim, California

**Muck Stripping**

The muck stripper consists of a vacuum assembly that presses the filter cake to squeeze out some of the solvent retained. The filter sludge is transferred from the muck stripper into a plastic bag. After about 5 min, the bag can be removed, and the dry muck sealed in the bag is ready for disposal. A new bag can be attached to the stripper to make it ready for the next load.

Only recently has filter muck been processed to recover Stoddard solvent for reuse. The one model of muck stripper now available can handle 45 gal (170 l) of solvent before the muck must be emptied. It can squeeze solvent out of filter cake at a rate of about 0.3 gal/lb (2.5 l/kg). For an average petroleum dry cleaner with a capacity of 250 lb (113 kg), the muck stripper would be used once a day. The average cycle time for the unit is 20 min.

**Use of Still Bottoms Waste**

The waste material left after the boildown of a vacuum still is typically composed of oils, lint, dirt, detergent, and solvent. The waste can be discarded, sold to an oil scavenger service, or burned on site as a fuel. A still-waste-burning system was evaluated in an EPA research project at a company that has been burning still waste with No. 4 fuel oil for several years. Burning of the still waste as an auxiliary fuel was found to be a feasible means of disposal with the potential to save user costs and reduce emissions of volatile organic compounds from petroleum dry cleaning plants.

**Incineration of Dryer Exhaust**

Incineration of dryer exhausts is feasible for petroleum vapors. Thermal incineration of petroleum solvents or boiler combustion would only be for large plants having large steam demands. Three problems appear, however:

- Auxiliary fuel is still needed because the solvent concentration is well below the lower explosive limit.
- The high exhaust volumes from the dryer necessitate a large incinerator.
- Local fire codes and other safety considerations may preclude the use of incineration.

## Fluorocarbon Solvent

To offset the high cost of F-113, recovery is essential. In spite of built-in controls—all fluorocarbon machines are nonvented systems with refrigerated condensers—possible emission points in an F-113 machine include:

- Dryer exhausts
- Cleaning wheel when the door is opened between loads
- Filter media that retain solvent
- Clothes that retain solvent
- Faulty gaskets or seals

Emissions from the last two sources would be low in a well-maintained, properly operated machine. In some machines, solvent retention by filter cartridges can be minimized by placing the cartridges in the cleaning wheel and running the unit through a drying cycle to evaporate and collect any retained solvent. The wheel is not rotated during this operation.

## 5. Economics

### Perchloroethylene Solvent

#### Carbon Adsorption

The capital cost of a carbon adsorber for a small commercial plant—25-lb (11-kg) machine—is about $4,000,[h] which represents about 7 percent of the total plant capital. For a larger commercial plant—50-lb (23-kg) machine—the capital cost for a carbon adsorber is again $4,000, or about 4 percent of the total dry cleaning plant capital. In the industrial sector—250-lb (110-kg) machine—the average capital cost for a carbon adsorber is $11,700, or about 3 percent of total dry cleaning plant capital.

[h]Costs in this report are in 1978 dollars unless otherwise specified.

Figure 1 compares the capital and net annual costs of two emission

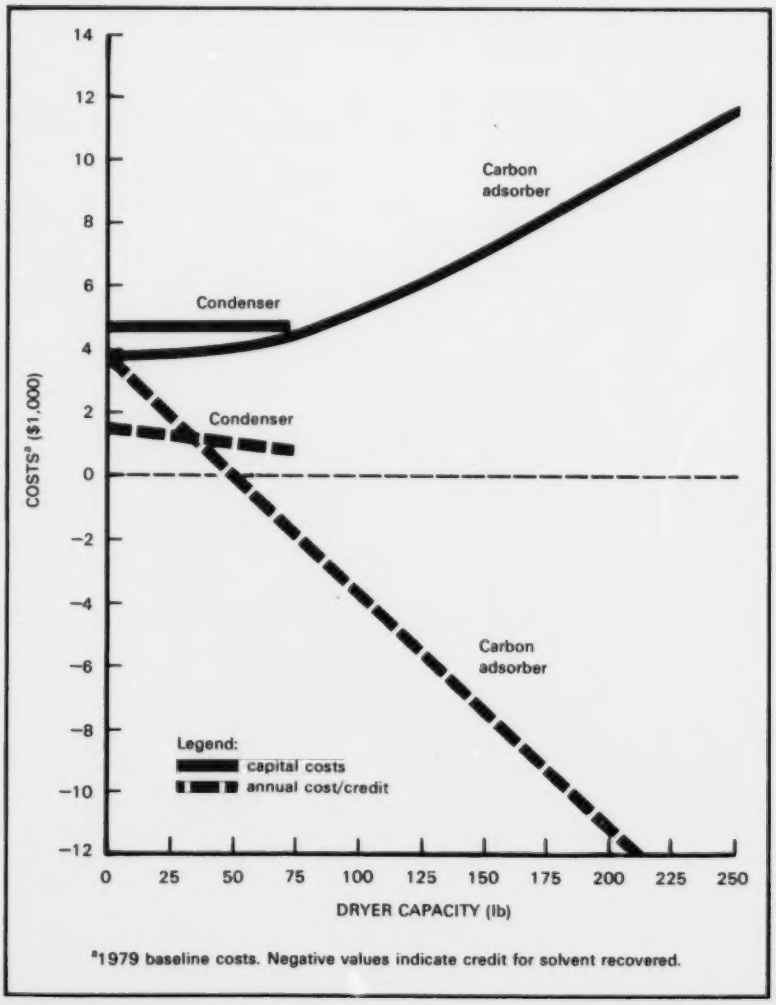



**Figure 1.**

Comparison of Capital and Net Annual Costs for Emission Control Equipment in Perchloroethylene Plants

control technologies for the various sizes of perchloroethylene dry cleaning plants. The annual costs are composed of amortized capital costs (control equipment and installation) and operating costs (electricity, maintenance of the control system, and steam).

The use of carbon adsorbers produces a credit for solvent recovered, and this credit is deducted from the annual costs. As Figure 1 shows, carbon adsorption is most economical for the industrial dry cleaner, who can actually show a profit from applying this solvent recovery system. Although no profit is shown for the small commercial dry cleaner, the equipment can be operated without significant effect on plant profitability.

#### Refrigeration/Condensation

The capital cost for a refrigeration/condensation unit on a 50-lb (23-kg) dryer is $4,850—$850 more than the cost of a similarly sized carbon adsorber. Operating costs are less than for the carbon adsorber because steam is not required. Annual operating costs for this installation are $450.

## Petroleum Solvent

#### Carbon Adsorption

The capital cost for the Anaheim carbon adsorption system is $128,300, including equipment, procurement, and installation. Because some of these cost items are site specific, control costs may be higher or lower for a system installed elsewhere. This capital cost, however, is average for a plant with a 400-lb (180-kg) dryer capacity. The annual cost for this carbon adsorption system is $30,100, based on a solvent value of $1.40/gal.

#### Condensation

Capital costs for the 50-lb (23-kg) and 105-lb (48-kg) condensation solvent recovery units are $14,500 and $15,000, respectively, or $10,900 and $9,940 more than for uncontrolled dryers without a recovery system.

The capital cost differences are high, but the savings in recovered solvent from the condensation dryer can, in some instances, lower this dryer's annualized cost to that of a conventional dryer. Machine capacity, solvent cost, and daily operation time should be considered when costs of the conventional and condensation recovery systems are compared.

#### Muck Stripping

The muck stripper is add-on equipment with a capital cost of $2,400, including installation.

The annual expense for the muck stripper includes the amortized cost of the stripper, maintenance, and electricity costs. The value of the recovered solvent, however, can reduce the muck stripper's annual expense substantially.

#### Incineration of Dryer Exhaust

Incineration of dryer exhaust is not considered an economically feasible control measure because of the high exhaust volumes associated with Stoddard solvent. The use of a separate incinerator would require large quantities of fuel for proper combustion of the solvent vapors. The use of in-house industrial boilers for incineration is not feasible because the large volumes of exhaust from the dryers cannot be handled by these relatively small boilers.

## Fluorocarbon Solvent

Detailed cost data are not available on F-113 control techniques because fluorocarbon emissions cannot be regulated by applying add-on controls to existing plants. The high cost of F-113 (approximately $12/gal in 1980 dollars) requires efficient solvent recovery to make fluorocarbon machines competitive with perc and petroleum machines.